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(54) A gas-liquid contacting apparatus

(57) A gas-liquid contacting apparatus 1 comprises an upwardly extending casing 2 having a number of frothing trays 6 to 8 extending across the casing interior at different levels, and perforated, packing trays 14, 16 partitioning the spaces between the frothing trays 6 to 8 into an upper packing section 18, 20 containing respective gas-liquid contacting packings 26, 28 and respective lower frothing sections, 22, 24.

Each frothing tray may be divided into - e.g. four - spaced portions spanning the width of the casing - Fig 2 (not shown).

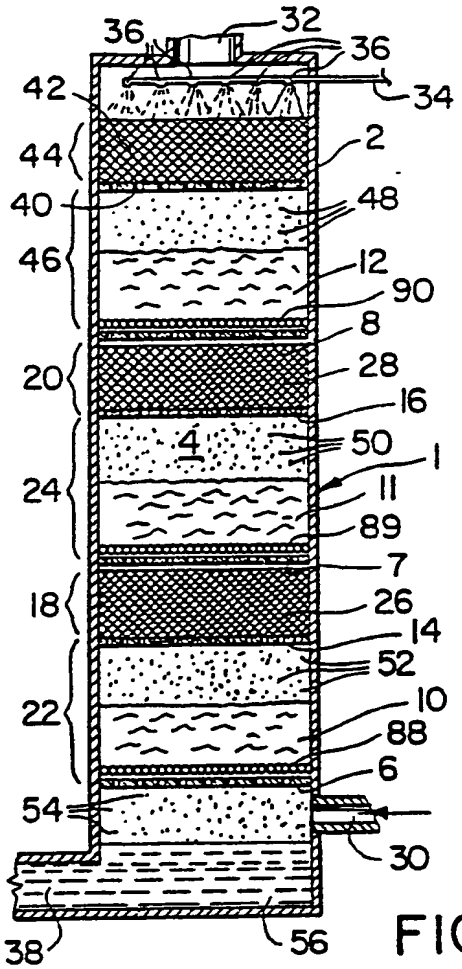

FIG. 1

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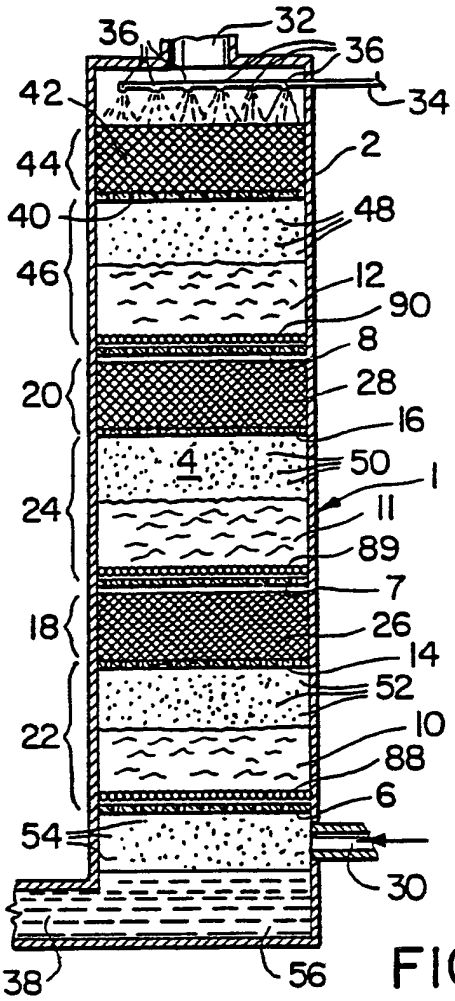

FIG. 1

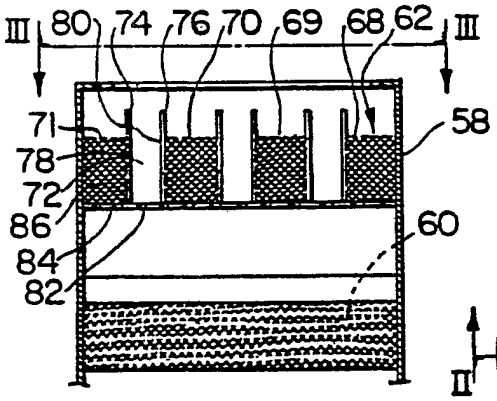

FIG. 2

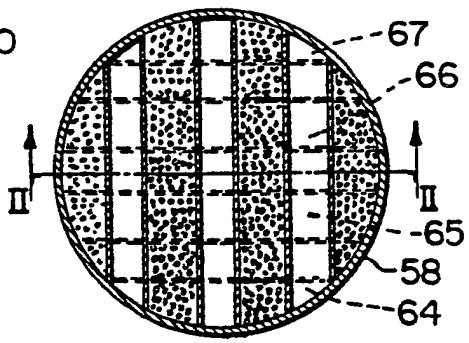

FIG. 3

A GAS-LIQUID CONTACTING APPARATUS

This invention relates to a gas-liquid contacting apparatus.

There are two types of gas-liquid contacting apparatus for use, for example, in distillation and absorption, and these are:

i) sieve or perforated trays which offer low efficiency and low cost, and

ii) random or ordered packed beds which are more efficient but which are also more expensive.

Sieve trays and packings are used extensively in gas-liquid contact applications such as distillation. In general, sieve trays are considered less efficient than the packings. This is in part due to the fact that there is a large space above the froth on the sieve tray that is not activé for mass transfer. If we consider a typical froth height of 150 mm and a tray efficiency of 60%, then the height equivalent to a theoretical plate (HETP) would be 250 mm, a value close to that for the high performance structured packing. However, the vapor-liquid disengagement space above the froth is necessary for maintaining hydraulic stability of the tower. This space is about 2-3 times the froth height and as a result the HETP for a sieve tray is about 700 mm. This HETP is similar to that for a low efficiency random packing but considerably higher than that for a structured or ordered packing.

There is a need for a gas-liquid contacting

apparatus which makes use of sieve or frothing trays and yet has high mass transfer rates and high gas-liquid throughput.

According to the present invention there is provided a gas-liquid contacting apparatus, comprising:

a) an upwardly extending casing forming a flow path for the flow of liquid downwardly therethrough and flow of gas upwardly therethrough,

b) a series of frothing trays extending across and partitioning the flow path in the casing at different levels, each tray being perforated for distributing liquid thereacross which has been frothed by upwardly flowing gas therethrough,

c) for each pair of frothing trays, a perforated, packing tray partitioning the portion of the flow path of the casing therebetween to provide a flow path packing section immediately beneath one of the frothing trays, and a flow path frothing section immediately above the lower one of those frothing trays, and

d) gas-liquid distributing packings in the packing section.

In some embodiments of the present invention an uppermost packing section is provided in the casing above the level of the uppermost frothing section, and gas-liquid distributing packings are provided in the uppermost packing section.

Each frothing tray may comprise a plurality of

spaced portions spanning the width of the interior of the casing, with the portions of one frothing tray traversing the portions of adjacent trays, for each space, between two portions of a frothing tray, a downcomer may be provided leading therefrom, each downcomer having perforated side walls and an impermeable lower wall, each packing tray then comprises a plurality of perforated, packing tray portions each closing a packing section beneath a frothing tray portion which is bounded by at least one downcomer, perforated side wall, and the gas-liquid distributing packings are then in each packing section beneath each frothing tray portion.

In some embodiments of the present invention, fluid permeable, gas distributing means are provided for each frothing tray, each fluid permeable, gas distributing means being adjacent the top side of the tray associated therewith for, in operation, breaking up any bubbles forming on the pores of that frothing tray.

Each fluid permeable, gas distributing means may be fibrous or filamentary material in open mat, felt or woven form.

Each fluid permeable, gas distributing means may be an open mesh.

In the accompanying drawings which illustrate, by way of example, embodiments of the present invention,

Figure 1 is a diagrammatic, sectional side view of a gas-liquid contacting apparatus,

Figure 2 is a diagrammatic, sectional side view along II-II, Figure 3 of a portion of a different gas-liquid contacting apparatus to that shown in Figure 1, and

Figure 3 is a diagrammatic, sectional plan view along III-III, Figure 2.

Referring now to Figure 1 there is shown a gas-liquid contacting apparatus, generally designated 1, comprising,

a) an upwardly extending cylindrical casing 2 forming a flow path 4 for the flow of liquid downwardly therethrough and flow of gas upwardly therethrough,

b) a series of frothing trays 6 to 8 extending across and partitioning the flow path 4 in the casing 2 at different levels, each tray 6 to 8 being perforated for distributing liquid thereacross which has been frothed, to form froths 10 to 12 respectively, by upwardly flowing gas therethrough,

c) for each pair of frothing trays 6, 7 or 7, 8, a perforated packing tray, 14 and 16 respectively, partitioning the portion of the flow path of the casing 2 therebetween to provide a flow path packing section, 18 and 20 respectively, immediately beneath the upper one, 7 and 8 respectively, of the frothing trays, and a flow path frothing section, 22 and 24 respectively,

immediately above the lower one, 6 and 7 respectively, of those frothing trays, and

d) gas-liquid distributing packings 26 and 28 in the packing sections 18 and 20 respectively.

The upwardly extending casing 2 has a gas inlet 30, a gas outlet 32, a liquid inlet pipe 34 feeding liquid spray nozzles 36 and a liquid outlet 38.

The packings 26 and 28 may be random packings or may be structured to form an ordered bed.

In this embodiment, a further, perforated, packing tray 40 is provided supporting a packed bed 42 in a packing section 44 beneath the liquid spray nozzles 36, and providing a frothing section 46 above the frothing tray 8.

In operation, gas is fed into the casing 2 through the inlet 30 while liquid is fed along the pipe 36 to the nozzles 36. The liquid is sprayed on to the packings 42 to trickle downwardly therethrough in a well distributed manner and emerge therefrom as droplets 48 which fall on to the frothing tray 8. The droplets 48 falling on to the frothing tray 8 form a liquid level thereon some of which is frothed, to form froth 12, by the gas passing upwardly through the casing 2 from the inlet 30. Some of the liquid on the frothing tray 8 escapes through the perforations to form droplets well distributed over the packings 28.

The droplets trickle downwardly through the

packings 28 and emerge as droplets 50 which fall on to the frothing tray 7 to form a liquid level thereon some of which is frothed, to form froth 11, by the gas passing upwardly through the casing 2. Some of the liquid on the frothing tray 7 escapes through the perforations to form droplets 52 which trickle downwardly through the packings 26 to fall as droplets on the frothing tray 6 where a liquid level is formed and froth 10 is made by upwardly flowing gas. Liquid escaping through the perforations in the frothing tray 6 forms droplets 54 which collect as liquid 56 which forms a liquid, draining seal.

It will be seen that gas passing upwardly through the casing 2 is brought into intimate contact with liquid passing downwardly therethrough because:

i) the usually inactive space above a frothing tray is used as a gas-liquid contacting section by partitioning the casing 2 above each tray to form an upper, packing containing section and a lower frothing section,

ii) the packings provide good distribution of the droplets falling gently through the frothing sections on to the frothing trays, and

iii) the frothing trays provide good distribution of the droplets falling through their perforations on to the packings.

The result is that in a gas-liquid transfer

operation such as methanol-water distillation, the apparatus according to the present invention can achieve a combined efficiency for the frothing trays and packings of, say, 135% compared with an efficiency of, say, 65% for a low cost, conventional apparatus containing only frothing trays where only a low throughput is possible.

Furthermore, the efficiency and/or throughput of an apparatus according to the present invention has been found to compare favorably with the more expensive apparatus containing only packed beds.

Also, when the gas flow is high, the packings have been found to serve as de-entrainment sections thus further improving the gas-liquid contact.

The provision of the extra packings 42 enhance the distribution of the sprayed liquid from the nozzle in addition to providing additional gas-liquid contact.

Tests to verify the present invention were carried out in a 6 inch diameter column for the distillation of methanol-water mixtures. A dual-flow tray was used with 318 mm tray packing, 7 mm hole diameter and 20% hole area combined with a 100 mm high structured packing supplied by Glitsch, Inc. under the trademark Gempack-350. The results indicated (1) a tray efficiency of $\sim$ 120-140% for an F-factor of 0.8 - 1.6 $kg^{\frac{1}{2}}.s^{-1}.m^{-\frac{1}{2}}$ and (2) a maximum operable F-factor = 1.8. This compares with an efficiency of

60% and maximum F-factor of 1.4 for a sieve or frothing tray with similar tray spacing.

Tests have shown that the packing sections need only be short, say 200mm, and so wall effects are insignificant.

The gas may be in the form of a vapour.

The frothing trays 6 to 8 may be provided with more perforations per unit area adjacent the casing 2 than at the center area of the trays 6 to 8 to provide better distribution of liquid over the packings 26 and 28.

The apparatus according to the present invention can be used in any distillation or absorption processes. The packings may be random packings, e.g., rings, spheres or saddles or structured or ordered bed packings, e.g. corrugated, rolled, screens or plates.

The apparatus according to the present invention can be in the form of a new apparatus or a modified existing apparatus.

The combination of low cost and high efficiency of an apparatus according to the present invention can result in substantial savings in, for example, the chemical, petroleum and paper industries.

Any known countercurrent tray arrangement, such as, for example, dual-flow trays, and multiple downcomer trays may be used.

Referring now to Figures 2 and 3, there is shown a multiple downcomer apparatus.

In Figures 2 and 3 there is shown a portion of a casing 58 containing two frothing trays generally designated 60 and 62. Each tray is divided into four spaced portions spanning the width of the interior of the casing, that is portions 64 to 67 of tray 60, and portions 68 to 71 of tray 62. The portions 64 to 67 traverse the portions 68 to 71 and any portions of any further trays that are provided will primarily traverse the portions of any adjacent trays.

The spaces between the tray portions, such as space 72 between tray portions 70 and 71, form drainage openings bounded by upstanding weirs 74 and 76 on the tray portions 70 and 71 The drainage openings, such as that formed by space 72 lead to spaced, parallel downcomers each having perforated side walls such as side walls 78 and 80, and an impermeable lower end wall, such as end wall 82.

The spaces beneath the frothing tray portions such as tray portion 71, and bounded by the perforated side walls, such as side wall 78, are packing sections and are each closed at the lower end by a perforated packing tray portion, such as packing tray portion 84, and are filled with packings, such as packings 86.

In operation, gas is passed upwardly through the casing 58 while liquid is sprayed into the upper end (not shown) of the casing 58 and gravitates downwardly therethrough.

Some of the liquid descending on to, say, the tray portions 68 to 71 is foamed by gas passing upwardly through, say, the packings 86, so that foam will overflow the weirs, such as weirs 74 and 76 and flow down the downcomers and through the perforated side walls, such as those designated 78 and 80. The remainder of the liquid descending on to, say, the tray portions 68 to 71 is distributed downwardly over, say, the packings 86.

Liquid entering, say, the packings 86 trickles downwardly to exit through the perforated plate 84 and fall onto the tray portions 64 to 67 where the same sequence of operations is repeated.

In different embodiments of the present invention, fluid permeable, gas distributing means 88 to 90, Figure 1, are provided for each frothing tray 6 to 8 respectively. Each fluid permeable, gas distributing means 88 to 90 being adjacent the top side of the tray, 6 to 8 respectively, associated therewith, for, in operation, breaking up any bubbles (not shown) forming on the pores (not shown) of that frothing tray 6 to 8.

The fluid permeable, gas distributing means 88 to 90 may be fibrous or filamentary material in open mat, felt or woven form.

The fluid permeable, gas distributing means may be an open mesh.

The fluid permeable, gas distributing means 88 to 90 achieve a more uniform froth formation on the trays 6 to 8.

The fluid permeable, gas distributing means 88 to 90 also assure a more uniform static head of liquid on the frothing trays 6 to 8 and a more uniform distribution of liquid across them. This gives a more uniform distribution of liquid gravitating downwardly through the trays 6 to 8.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving

the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

WE CLAIM:

1. A gas-liquid contacting apparatus, comprising:

a) an upwardly extending casing forming a flow path for the flow of liquid downwardly therethrough and flow of gas upwardly therethrough,

b) a series of frothing trays extending across and partitioning the flow path in the casing at different levels, each tray being perforated for distributing liquid thereacross which has been frothed by upwardly flowing gas therethrough,

c) for each pair of frothing trays, a perforated, packing tray partitioning the portion of the flow path of the casing therebetween to provide a flow path packing section immediately beneath one of the frothing trays, and a flow path frothing section immediately above the lower one of those frothing trays, and

d) gas-liquid distributing packings in the packing section.

2. An apparatus according to claim 1, wherein an uppermost packing section is provided in the casing above the level of the uppermost frothing section, and gas-liquid distributing packings are provided in the uppermost packing section.

3. An apparatus according to claim 1 or claim 2 wherein each frothing tray may comprise a plurality of spaced portions spanning the width of the interior of the casing, with the portions of one frothing tray traversing the portions of adjacent trays, for each space, between two portions of a

frothing tray, a downcomer may be provided leading therefrom, each downcomer having perforated side walls and an impermeable lower wall, each packing tray then comprises a plurality of perforated, packing tray portions each closing a packing section beneath a frothing tray portion which is bounded by at least one downcomer, perforated side wall, and the gas-liquid distributing packings are then in each packing section beneath each frothing tray portion.

4. An apparatus according to any of the preceding claims, wherein fluid permeable, gas distributing means are provided for each frothing tray, each fluid permeable, gas distributing means being adjacent the top side of the tray associated therewith for, in operation, breaking up any bubbles forming on the pores of that frothing tray.

5. An apparatus according to claim 4, wherein each fluid permeable, gas distributing means may be fibrous or filamentary material in open mat, felt or woven form.

6. An apparatus according to claim 4, wherein each fluid permeable, gas distributing means may be an open mesh.

7. A gas-liquid contacting apparatus comprising a tube within which there is provided a transverse perforated frothing tray and a transverse perforated packing tray.

8. Apparatus according to claim 7 in combination with apparatus according to any of claims 1 to 6.

9. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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